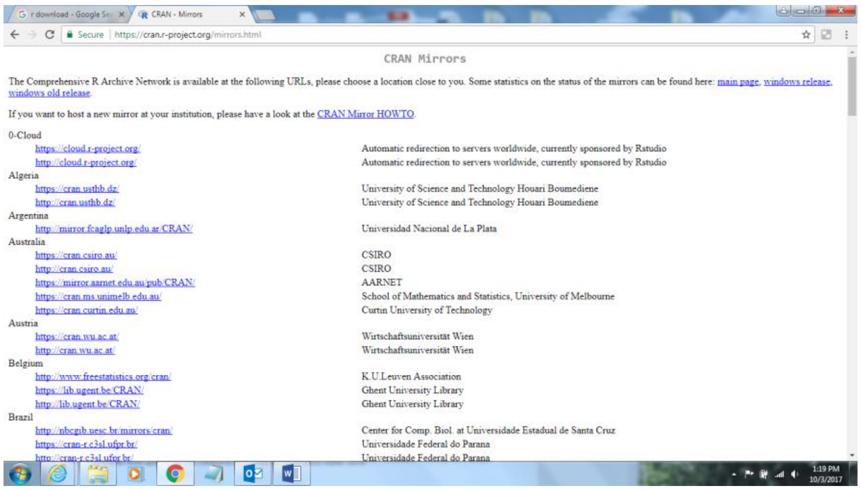
Computer code for calculation of the L factors

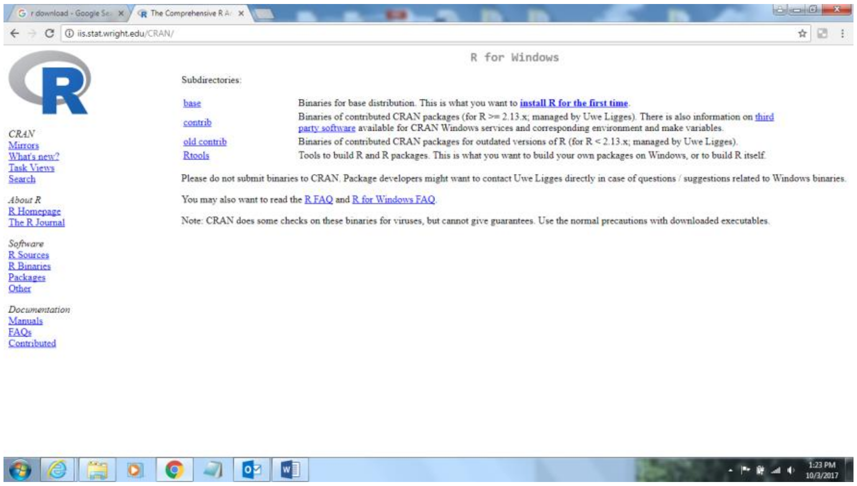
The code requires that both R and OpenBUGS be installed, both are free to download.
R can be obtained at http://www.R-project.org/

1. Click on “download R” this will appear:



2. Scroll down to USA and pick one of the sites:

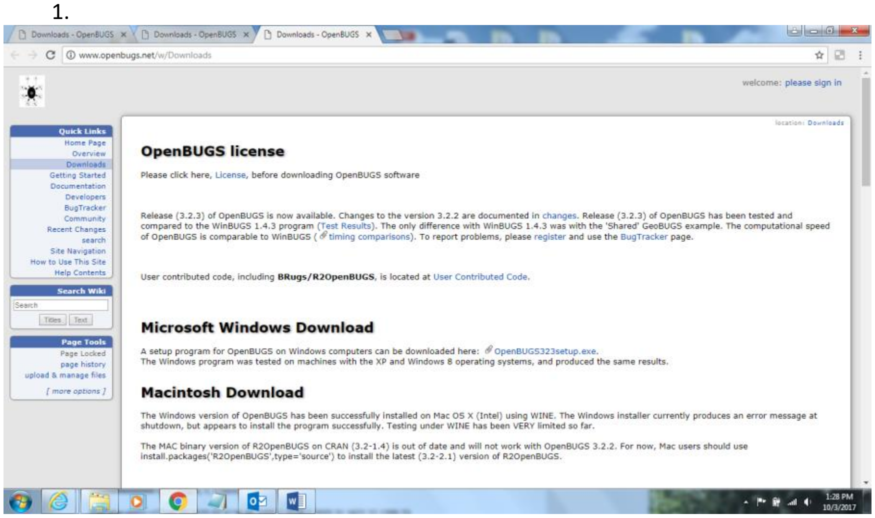
3. Download the R version appropriate for your system.



4. Click “install R for the first time and follow instructions.

OpenBUGS can be obtained at http://www.openbugs.net/w/Downloads .

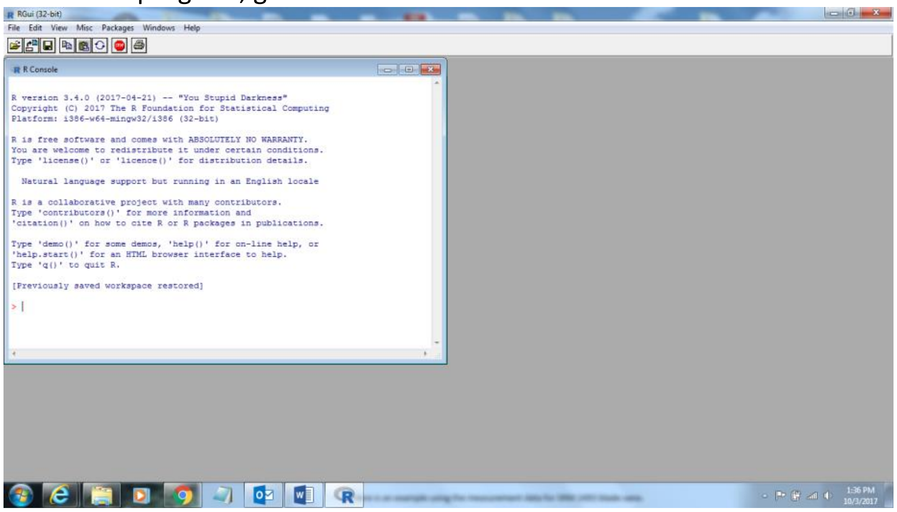
1.



2. Click on the download for your system
3. Run the installer.

To run the program:

1. Start the R program, get this:



2. The only input to the program that is needed are the values N and Γ, and the sample size n. In the program below x = N in rad/s, and y = Γ in µNm.

For example, SRM 2497 with spiral concrete paste data:

SR (1/s)	**Viscosity (Pa.s)**
10.5105	0.052329
7.5642	0.054203
5.4411	0.056974
3.91545	0.061296
2.8182	0.067419
2.0223	0.074173
1.4595	0.08222
1.05105	0.095143
0.756	0.10582
0.5439	0.1287
0.39165	0.153198
0.2814	0.177683
0.20265	0.197385
0.14595	0.274066
0.105	0.380952
0.0756	0.396825
0.0546	0.549451
0.03885	0.772201

0.02835	1.058201
0.01995	1.503759
0.0147	2.040816
0.010395	2.886003

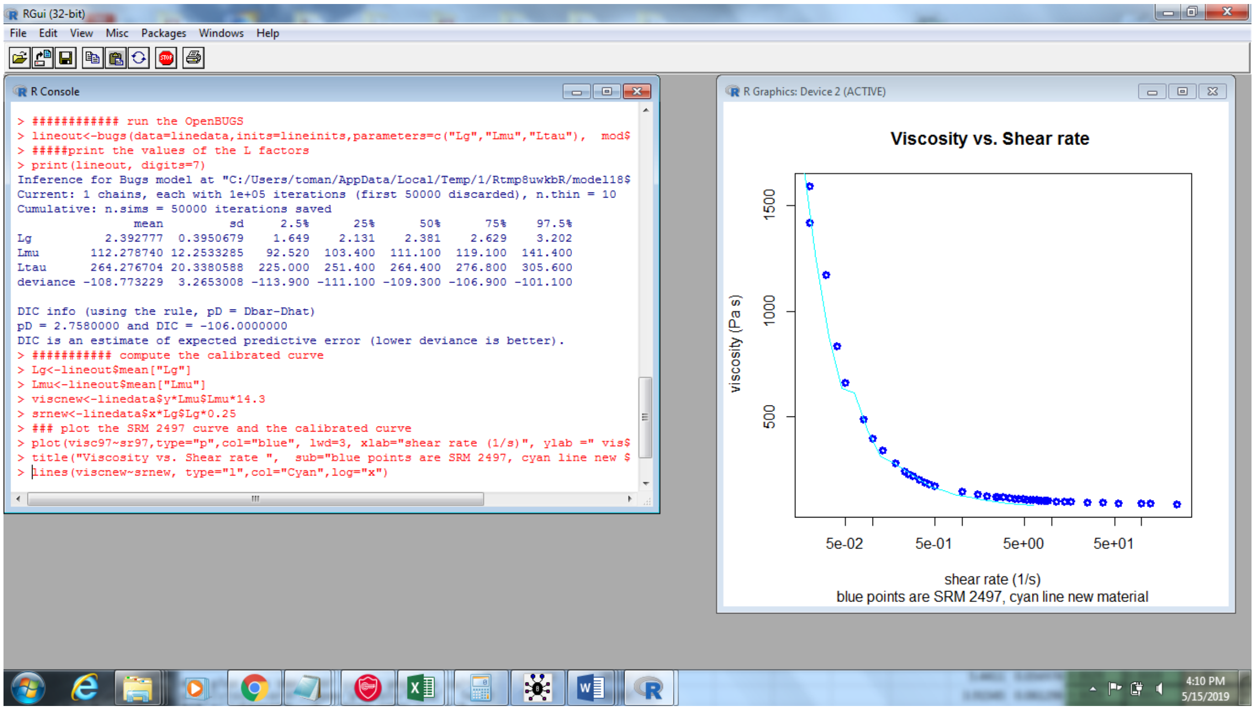
3. Paste the entire program below into a notepad window:

```
######################################################################################
library(R2OpenBUGS)

############## type data X (in rad/s), Y (in µNm) , n here:

linedata<-
list(y=c(0.0523,0.0542,0.0570,0.0613,0.0674,0.0742,0.0822,0.0951,0.1058,0.1287,0.1532,
0.1777,0.1974,0.2741,0.3810,0.3968,0.5495,0.7722,1.0582,1.5038,2.0408,2.8860
),
x=c(10.5105,7.5642,5.4411,3.9155,2.8182,2.0223,1.4595,1.0511,0.7560,0.5439,0.3917,
0.2814,0.2027,0.1460,0.1050,0.0756,0.0546,0.0389,0.0284,0.0200,0.0147,0.0104), n=22)

###############

####SRM 2497 curve for comparison to see the fit
visc97<-
c(88.1,89.5,90.1,92.1,93.7,95.8,98.6,99.9,101.6,103.5,104.1,104.7,105.3,106.0,106.8,107.7,
108.7,109.8,111.1,112.7,114.4,116.6,119.2,122.1,122.8,127.5,134.5,146.3,171.5,182.1,191.4,
203.5,219.8,230.3,243.1,279.1,342.8,397.5,487.1,662.4,833.8,1168.9,1415.3,1589.3
)

sr97<-
c(250.0,125.0,100.0,55.0,37.5,25.0,16.3,13.8,11.3,9.1,8.7,8.2,7.7,7.2,6.8,6.3,5.8,5.3,4.8,4.3,3.9,
3.4,2.9,2.5,2.4,1.9,1.5,1.0,0.50,0.43,0.38,0.33,0.28,0.25,0.23,0.18,0.13,0.10,0.08,0.05,0.04,0.03,
0.02,0.02)
#####
##### OpenBUGS code and inits

lineinits<-function(){list(sig=1)}
linemodel <- function() {sig~dgamma(1.0E-5,1.0E-5)
Lg~dunif(0.5,10)
Lm~dunif(0,4)
Lmu<-1/Lm
Ltau<-Lg/Lm

a<--4
```

```
a2n<-8.89
a2sig<-1/(0.18*0.18)
b2n<-0.53
b2sig<-1/(0.06*0.06)
c2n<-5.94
c2sig<-1/(0.24*0.24)
a1n<-8.62
a1sig<-1/(1.18*1.18)
b1n<-0.94
b1sig<-1/(0.05*0.05)
c1n<-7.49
c1sig<-1/(0.35*0.35)
 a2~dnorm(a2n,a2sig)
b2 ~dnorm(b2n,b2sig)
c2 ~dnorm(c2n,c2sig)
a1 ~dnorm(a1n,a1sig)
b1 ~dnorm(b1n,b1sig)
c1 ~dnorm(c1n,c1sig)
for (i in 1:n){ srd[i]<-x[i]*Lg
                num[i]<-a*srd[i]
                top[i]<-a*(srd[i]-1)
mu[i]<-Lm*(c2*exp(a)+c1*exp(num[i])+a1*exp(num[i])/pow(srd[i],b1)+a2*exp(a)/
pow(srd[i],b2))/(exp(a)+exp(num[i]))
y[i]~dnorm(mu[i],sig)
               }}
############ run the OpenBUGS
lineout<-bugs(data=linedata,inits=lineinits,parameters=c("Lg","Lmu","Ltau"),
model.file=linemodel,n.chains=1,n.iter=100000,n.burnin=50000,n.thin=10)
#####print the values of the L factors
print(lineout, digits=7)
########### compute the calibrated curve
Lg<-lineout$mean["Lg"]
Lmu<-lineout$mean["Lmu"]
viscnew<-linedata$y*Lmu$Lmu*14.3
srnew<-linedata$x*Lg$Lg*0.25
### plot the SRM 2497 curve and the calibrated curve
plot(visc97~sr97,type="p",col="blue", lwd=3, xlab="shear rate (1/s)", ylab =" viscosity (Pa s)",
log="x")
title("Viscosity vs. Shear rate ",  sub="blue points are SRM 2497 paste, cyan line new material")
lines(viscnew~srnew, type="l",col="Cyan",log="x")
##############################################################################
```

4. Edit the X and Y lists to input your own data.
5. Paste the entire edited file into the R window.

6. This will run the code and produce the estimates of the *L* factors as well as a plot which shows the fit to the SRM 2497 function.



7. Read the L factors as: L_{γ} (Lg in the output)
   L_{μ} in Pa s / N m s (1000000 Lmu in output),
   L_{τ} Pa/N m (1000000 Ltau in output).